Data-Driven Study of Shape Memory Behavior of Multi-Component Ni-Ti Alloys

Shreyas J. Honrao (KRB Inc, NASA ARC), Othmane Benafan (NASA GRC), John W. Lawson (NASA ARC)

Ni-Ti based shape memory alloys (SMAs) have found wide-spread use in aerospace, automotive, biomedical, and commercial applications owing to their favorable properties and ease of operation. Especially important for many NASA applications is the ability to tune the martensitic transformation temperature of Ni-Ti alloys by varying the alloy composition and processing conditions. Recently, researchers at NASA have compiled an extensive database of shape memory properties of materials, including over 8,000 multi-component Ni-Ti alloys containing 37 different alloying elements. Using this dataset, machine learning models are trained to predict transformation temperatures, hysteresis, and transformation strain with extremely low mean absolute errors. These models are used to learn relationships between shape memory behavior and input parameters in the composition and processing space. ML predictions are validated through new experiments. The combination of an extensive experimental dataset and accurate learning models, together, make our approach highly suitable for the rapid discovery and design of novel SMAs with targeted properties. We are not aware of any current approaches capable of predicting SMA transformation behavior over such a wide range of compositions and processing conditions.